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BIOLOGICAL EVALUATION
Western Spruce Budworm

Kaibab National Forest
and Grand Canyon National Park

1979

Forest Insect and Disease Management
State and Private Forestry
Southwestern Region, USDA Forest Service
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ABSTRACT

The western spruce budworm, Choristoneura occidentalis Free., outbreak continued for the fifth consecutive year on the Kaibab Plateau, Kaibab National Forest and Grand Canyon National Park, Arizona. Acres of forest defoliated by this budworm by year follow: 1975, 781; 1976, 67,320; 1977, 70,720; 1978, 39,501; 1979, 53,811.

Damage surveys made in three stands in 1979 showed that 9, 11, and 14 percent of the trees repeatedly infested by this insect were top-killed.

The average egg mass density in 1979 was about the same as the density recorded in 1978, and the overall infestation is expected to remain at a high level in 1980. The density of egg masses was very high at several locations sampled, and stands near these locations should be moderately to heavily defoliated in 1980.

The western spruce budworm outbreak is expected to continue for several years on the Kaibab Plateau.

Pest management alternatives and recommendations are discussed in this evaluation report.

INTRODUCTION

The current western spruce budworm, Choristoneura occidentalis Free., outbreak has defoliated mixed conifer stands on the Kaibab Plateau, Kaibab National Forest and Grand Canyon National Park, since 1975. Total acres of forest defoliated for the years 1975 to 1978 were: 781, 67,320, 70,720, and 39,501, respectively. Even though the amount of visible defoliation decreased significantly from 1977 to 1978, which would indicate a decline in the outbreak, the infestation actually remained at a high level. Weather conditions--abundant and well-spaced precipitation--favored tree growth in 1978, and the additional foliage helped to mask defoliation. Based on egg mass density data collected last year (Lessard 1978), an intensification of the outbreak on the Forest and in the Park was forecast for 1979. Tree damages were expected to begin in 1979, since some stands would have been heavily defoliated for a third consecutive year.

Tree damage and insect density data were collected in 1979, and they are summarized in this report. Management alternatives and recommendations are also discussed.

TECHNICAL INFORMATION

Insect.--Western spruce budworm, Choristoneura occidentalis Freeman

Hosts.--Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco
White fir, Abies concolor (Gord. & Glend.) Lindl.
Subalpine fir, Abies lasiocarpa (Hook.) Nutt.
Blue spruce, Picea pungens Engelm.
Engelmann spruce, Picea engelmannii Parry

Life History.--The western spruce budworm completes one generation each year (Furniss and Carolin 1977).

Stage	Time	Location on Host
egg	August	on needles
small larvae	overwinter	in hibernaculum (silken web) on branches and trunk
large larvae	June	on buds and strobile
pupae	July	on foliage
adults	August	in flight

Evidence of Infestation.

1. Young larvae feeding on newly expanding buds and strobile. ?
2. Mature larvae consuming current year's needles.
3. Shoots webbed together by larvae.

4. Webbed shoots turning brown and falling from trees.
5. Defoliation most evident in upper crowns of trees.
6. Trees dying from the top downward after several years of heavy defoliation.

Extent of Defoliation in 1979.--Defoliation was visible from the air on 53,811 acres (21,793 hectares) of the North Kaibab Entomological Unit, Kaibab Plateau (Fig. 1, Appendix). Severity of defoliation was categorized as: light, 34,355 acres (13,906 hectares); moderate, 18,099 acres (7,330 hectares); heavy, 1,357 acres (550 hectares). Sampling and on-the-ground observations of defoliation confirmed that the aerial observations were underestimates, and the actual defoliation was more intense than estimated during the 1979 aerial survey.

BIOLOGICAL INFORMATION

Estimation of Damage.

Methods.--Damage surveys were conducted in three mixed conifer stands defoliated since 1976 (Fig. 1, Appendix). The sizes of the survey blocks were: Upper Tater Canyon, 75 acres; Upper North Canyon, 75 acres; Quaking Aspen Canyon, 8 acres.

Sample points (1/100-acre fixed plots) were systematically located in each stand. In Upper Tater and Upper North Canyons, 30 plots were sampled with 10 plots being located on three survey lines. Sample points were located at 5-chain intervals. Twenty plots were sampled in Quaking Aspen Canyon, with 10 plots located on each of two lines. Between-plot spacing was at 2-chain intervals in this survey tract.

The species, diameter, and condition (live and top-killed) of "count" trees were recorded on sample plots. Ponderosa pines were not recorded, although they occurred in the stands sampled. It must be emphasized that it is difficult to accurately determine if a tree has been top-killed by the budworm. Only those trees that appeared obviously top-killed were recorded, even though some may be still alive. Conversely, many trees that were completely defoliated in the upper crown, which were not recorded as being top-killed, may be dead or will die before next spring. The only accurate way to determine if a tree has been top-killed is to establish permanent plots and repeatedly check trees for new growth.

Results.--Survey data collected in the three survey blocks show that permanent tree damage began to occur as a result of the repeated defoliation (Tables 1-3, Appendix). Top-killing of trees was the only damage noted; however, growth loss is occurring and there may be some mortality of understory trees in some stands. Dead trees were not observed in survey areas. A few sawtimber-size true firs were

top-killed in Upper Tater and Quaking Aspen Canyons, but the majority of trees affected were seedlings and pole-size true firs and spruce (Fig. 2, Appendix). Top-killing of understory Douglas-fir was not as severe as it was in white fir and Engelmann spruce.

A resume of stand data for each survey block follows:

Upper Tater Canyon (Table 1, Appendix).

Total trees/acre:	867
Live trees/acre:	770
Top-killed trees/acre:	97
Percent of stand alive:	89
Percent of stand top-killed:	11

Upper North Canyon (Table 2, Appendix).

Total trees/acre:	796
Live trees/acre:	726
Top-killed trees/acre:	70
Percent of stand alive:	91
Percent of stand top-killed:	9

Quaking Aspen Canyon (Table 3, Appendix).

Total trees/acre:	905
Live trees/acre:	780
Top-killed trees/acre:	125
Percent of stand alive:	86
Percent of stand top-killed:	14

Relative Abundance of Pest

Methods.--Egg mass density sampling was done in early August to provide an indication of the probable abundance of larvae in 1980 and the corresponding defoliation. Two branches (70 cm in length) were cut from opposite sides of the midcrown of three sample trees on 20 permanent plots (Fig. 1, Appendix). Sample trees met the following criteria: Douglas-fir, dominant or codominant; 30 to 50 feet in height; relatively open-grown with a full crown; and some budworm feeding evident, but the tree could not be severely defoliated or top-killed. Each branch was individually bagged in 1/4-bushel paper sacks, sealed, labeled, and transported to a laboratory for examination. All sacks were stored in a walk-in cooler at about 40° F.

In the laboratory, foliage was examined under ultraviolet light for budworm egg masses. Needles bearing egg masses were classed as from current year's foliage, or a previous year's foliage, and kept separate in labeled pill boxes. New and old egg masses were separated under a stereomicroscope. All egg masses on current year's foliage

were classed as new, and their characteristics formed the basis for aging egg masses found on the previous year's foliage.

Defoliation predictions for 1980 were determined from the density of 1979 egg masses using the following information presented by McKnight et al. (1970):

Egg mass density [a/]	Predicted defoliation class [b/]
<1.55	Undetectable for all infestations
1.71 to 6.20	Undetectable for "static" infestations Light for "increasing" infestations
9.30 to 31	Light for "static" infestations Moderate for "increasing" infestations
>34.10	Moderate for "static" infestations Heavy for "increasing" infestations

a/ Number of egg masses per square meter of foliage.
b/ Defoliation class limits (percent of new growth).
Undetectable = <5 percent
Light = 5 to 35 percent
Moderate = 35 to 65 percent
Heavy = >65 percent

Results.--Egg mass density data show that larval densities and defoliation in 1980 will vary considerably (Table 4). Mixed conifer stands near sample points 1, 2, 8, 10, and 11 will have little or no defoliation, while other stands will have light to heavy defoliation. The heaviest defoliation should continue to occur in an area of 1 to 2 miles wide on both sides of Pleasant Valley from VT Lake on the Forest, south to about 2 miles into the Park (Fig. 1, Appendix).

In 1980, the budworm infestation on the Kaibab Plateau should remain at a high level, although the overall average density is slightly lower than the density recorded in 1978. A summary follows:

	1976	1977	1978	1979
New egg masses per m^2 of foliage	17.6	28.4	31.8	25.8 [1/]
Ratio of new egg masses in a year: new egg masses the previous year	0.9:1	1.6:1	1.1:1	0.8:1

1/ The standard error of the mean was 4.7.

In general, defoliation on the Forest and in the Park should be moderate.

Prediction of Trend.

The western spruce budworm outbreak is expected to continue at a high level on the Forest and in the Park. The mixed conifer forest will remain highly susceptible, and, barring an unusual weather condition, which could cause a catastrophic decline in the budworm outbreak, the infestation is expected to continue for several years. As previously mentioned, the heaviest defoliation should occur south of VT Lake on the ridges on both sides of Highway 67 on the Forest and for about 2 miles in the Park.

ALTERNATIVES

Maintain Present Management.--With this approach, the outbreak would be allowed to run its course until a population collapse occurred from a combination of: 1) a lack of foliage to maintain a larval population; 2) unfavorable weather conditions; 3) heavy predation and parasitism; and 4) a viral or bacterial epizootic. Adverse and beneficial effects of the outbreak would be accepted.

Silvicultural Management.--Silvicultural treatments in mixed conifer stands would be designed to create stand conditions that would reduce tree damages due to this budworm. For example, prescriptions should: 1) open up stands by logging, thinning, and burning; 2) maintain stand densities to favor ponderosa pine; 3) prescribed burning would be used to reduce the percentage of true firs and Engelmann spruce; 4) regenerate stands by artificial means using ponderosa pine stock; 5) even-aged stands would be favored; and 6) salvage damaged and insect-killed trees. Treatments would be developed by a certified silviculturist and would be done only where appropriate. The current outbreak and the resulting tree damages would not be affected by using this alternative. Silvicultural management would be considered as a long-term approach; however, the effectiveness of these treatments have not been demonstrated.

Direct Suppression.--Aerial application of a pesticide registered by the Environmental Protection Agency (EPA) could be done to suppress the outbreak. The entire infested area, where larval densities are greater than one larva per 100 buds, would have to be treated to insure that a second treatment would not be needed during the present infestation cycle. Application would be carefully timed to the development of the larvae, i.e., when 20 percent of the larvae are in the fifth and sixth instars. This would insure maximum effectiveness with a minimal dosage of an insecticide. An application of this type is designed to utilize indigenous natural control agents to further reduce and maintain the budworm population at a low level (Parker et al. 1979).

Insecticides registered for use against the budworm follow:

1. Carbaryl (carbamate insecticide)

The Sevin®-4-oil formulation of carbaryl has given consistently satisfactory results in suppressing budworm outbreaks throughout the West. An outbreak on the Santa Fe National Forest, New Mexico, was successfully suppressed in 1977, and the outbreak has remained at a low level for 3 years (Parker et al. 1979). Carbaryl is a non-persistent pesticide which is available for general public use. One (1) pound of active ingredient per acre is the registered dosage rate, and no lasting environmental effects have been identified at this application rate.

2. Orthene® (organophosphate insecticide)

Orthene® is a non-persistent insecticide registered for use against the western spruce budworm and other forest defoliators. It has been shown to be effective against the budworm, but further evaluation of the material is needed before it can be recommended for large-scale operational suppression programs.

3. Malathion (organophosphate insecticide)

Malathion is a non-persistent, broad spectrum insecticide, registered for use against more than 100 insects, including the western spruce budworm. However, its use is not recommended because it has yielded inconsistent results in suppressing outbreaks.

4. Microbial Insecticides

Microbial insecticides, such as *Bacillus thuringiensis* (*B.t.*), a bacterium, and viruses need further research testing and field evaluation before they will be ready for operational use. There may be an opportunity to test *B.t.* in conjunction with the CANUSA Program,[2/] and suppression, which would be a secondary objective, might be achieved in selected stands.

Partial Chemical Treatment.--This alternative would involve aerial application of an EPA-registered insecticide on only National Forest land. The adjoining budworm infestation on the North Rim of Grand Canyon National Park would not be treated. There are no data available to show that this approach would be efficacious, although some pest management specialists believe lasting protection could be

2/ The Canada/U.S. Spruce Budworms Program (CANUSA--West) is a 6-year research and development program that is funded through 1983.

achieved. Conversely, it is possible that this strategy would require one or two repeat treatments because treated stands could be reinfested from nearby areas that were not treated.

There are other "partial treatment" approaches that could be considered.

RECOMMENDATION

Management of the Current Outbreak.--Direct suppression of the entire infested area is recommended if the economic benefits of this alternative can be shown to exceed the costs. Otherwise, the "Maintain Present Management" alternative is recommended.

From an entomological standpoint, each alternative must be evaluated using three criteria: 1) The management approach must be effective; 2) the total costs of an action should not exceed the benefits derived from a program; and 3) the selected action should not cause any lasting adverse environmental effects. A discussion of alternatives in respect to these criteria follows:

1. Maintain Present Management

a. This alternative would not be effective in preventing additional tree damages due to the western spruce budworm. The maximum tree damages that could occur during the current outbreak would be:

	Tree damages	Maximum damage (Percent)
1.	Growth loss	30
2.	Understory top-kill & mortality	25
3.	Sawtimber mortality	5
4.	Top-kill of sawtimber-size trees	25
5.	Cone crop reduction	90+
6.	Christmas tree use reduction	90+

b. There would be no direct costs associated with selection of this alternative, although timber values will be affected and revenues will be reduced when harvesting is done in timber sale areas. Also, the depletion of understory trees below adequate stocking levels could necessitate the expenditure of funds for reforestation.

c. Visual qualities and economic and social impacts would result if this alternative was selected.

2. Silvicultural Management

a. The trend of the current outbreak would not be changed if a silvicultural program was initiated. Tree damages would be the same as those listed under the "Maintain Present Management" alternative.

b. Conversion of mixed conifer stands to a less susceptible state would be very costly, and no short-term benefits could be achieved.

c. Again, visual qualities and economic and social impacts would result if this alternative was selected.

3. Direct Suppression

a. Suppresssion of the budworm outbreak could be achieved by using this alternative.

b. It would cost about $8.00 per acre to suppress the outbreak. Most of the tree damages previously listed under the "Maintaining Present Management" alternative would be prevented. A comprehensive cost/benefit evaluation must be done to determine if the benefits exceed the costs.

c. Adverse environmental effects resulting from the aerial application of an insecticide would be minimal and temporary.

4. Partial Chemical Treatment

a. No data are available to show that this alternative would be effective.

b. If this approach cannot be shown to be effective, it would be impossible to determine benefits. The cost would be the same as direct treatment (ca. $8.00 per acre).

c. Adverse environmental effects would be minimal and temporary.

Long-Term Pest Management--Kaibab National Forest

Where it is practical, silvicultural treatments to favor ponderosa pine and/or aspen in mixed conifer stands are recommended as a long-term approach to this pest problem. This could be accomplished through the timber and fire management programs.

LITERATURE CITED

Furniss, R. L. and V. M. Carolin. 1977. Western forest insects. USDA, Forest Serv. Misc. Publ. No. 1339. 654 pp.

Lessard, E. D. 1978. Biological evaluation, western spruce budworm. USDA, Forest Serv. Office Rep. R-3 79-1. 45 pp.

McKnight, M. E., J. F. Chansler, D. B. Cahill, and H. W. Flake, Jr. 1970. Sequential plan for western spruce budworm egg mass surveys in the central and southern Rocky Mountains. USDA, Forest Serv. Res. Note RM-174. 5 pp.

Parker, D. L., E. D. Lessard, and R. E. Acciavatti. 1979. Western spruce budworm suppression and evaluation project using carbaryl, 1978. USDA, Forest Serv. Progress Rep. No. 2. R-3 79-8. 109 pp.

APPENDIX

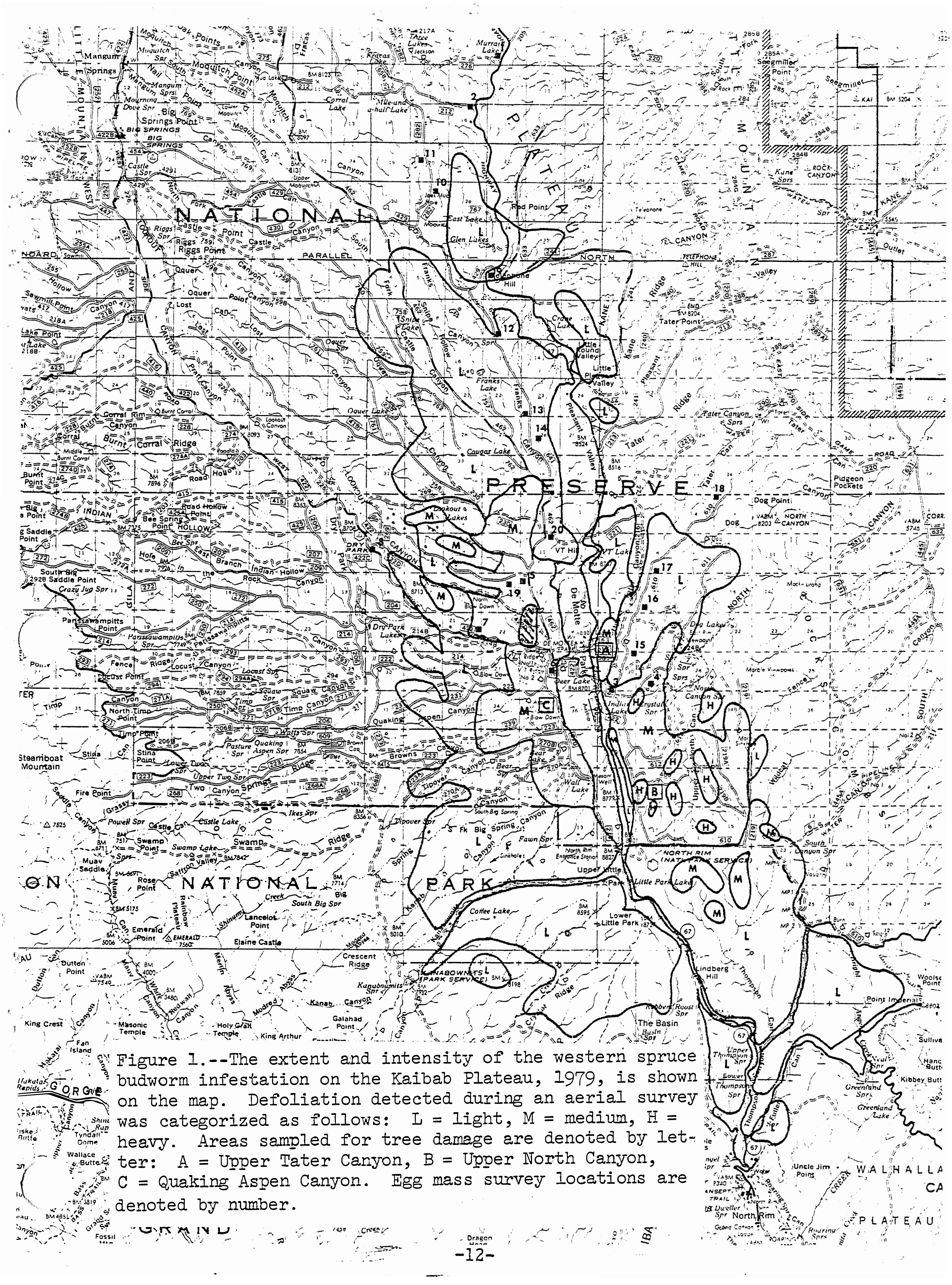

Figure 1.--The extent and intensity of the western spruce budworm infestation on the Kaibab Plateau, 1979, is shown on the map. Defoliation detected during an aerial survey was categorized as follows: L = light, M = medium, H = heavy. Areas sampled for tree damage are denoted by letter: A = Upper Tater Canyon, B = Upper North Canyon, C = Quaking Aspen Canyon. Egg mass survey locations are denoted by number.

Figure 2.--Trees top-killed by the western spruce budworm after 3 years of repeated defoliation, North Kaibab Ranger District, Kaibab National Forest, 1979.

Table 1.--Stand table for the Upper Tater Canyon damage survey block showing the species and diameter distribution of live trees and trees top-killed by the western spruce budworm, North Kaibab Ranger District, Kaibab National Forest, 1979 (Fig. 1, Appendix).

Size Classes a/	Live Trees/Acre b/				Top-killed Trees/Acre				Total Trees/Acre	Percent of Stand	
	DF	TF	SP	Total	DF	TF	SP	Total		Live	Top-killed
Seedlings	10.0	296.7	96.7	403.4	6.7	30.0	6.7	43.4	446.8	47	5
<1	3.3	10.0	33.3	46.6	---	3.3	---	3.3	49.9	5	<1
1	10.0	16.7	46.7	73.4	3.3	---	---	3.3	76.7	8	<1
2	6.7	10.0	20.0	36.7	---	3.3	---	3.3	40.0	4	<1
3	---	6.7	26.7	36.7	---	6.7	6.7	13.4	50.1	4	2
4	---	13.3	10.0	23.3	3.3	6.7	---	10.0	33.3	3	1
5	---	16.7	6.7	23.4	3.3	---	---	3.3	26.7	3	1
6	---	16.7	6.7	23.4	---	---	---	---	23.4	3	---
7	---	6.7	13.3	20.0	---	3.3	---	3.3	23.3	2	<1
8	3.3	3.3	6.7	13.3	---	---	---	---	13.3	2	---
9	---	6.7	6.7	13.4	---	---	---	---	13.4	2	---
10	---	3.3	6.7	10.0	---	---	---	---	10.0	1	---
11	---	3.3	13.3	16.6	---	3.3	3.3	6.6	23.2	2	<1
12	---	3.3	---	3.3	---	---	---	---	3.3	<1	---
13	3.3	---	3.3	6.6	---	3.3	---	3.3	9.9	1	<1
14	---	---	---	---	---	3.3	---	3.3	3.3	---	<1
15+	3.3	6.7	10.0	20.0	---	---	---	---	20.0	1	---
Total	43.2	420.1	306.8	770.1	16.6	63.2	16.7	96.5	866.6	89	11
Percent	5	48	35	89	2	7	2	11	100		

a/ Seedlings = trees 1 - 4.5 feet in height
<1 inch class = trees 4.5 feet in height to 0.9 inches in diameter
1 inch class = trees 1.0 - 1.9 inches in diameter, etc.

b/ DF = Douglas-fir
TF = True firs
SP = Spruce

Table 2.--Stand table for the Upper North Canyon damage survey block showing the species and diameter distribution of live trees and trees top-killed by the western spruce budworm, North Kaibab Ranger District, Kaibab National Forest, 1979 (Fig. 1, Appendix).

Size Classes a/	Live Trees/Acre b/				Top-killed Trees/Acre				Total Trees/Acre	Percent of Stand	
	DF	TF	SP	Total	DF	TF	SP	Total		Live	Top-killed
Seedlings	106.7	163.3	63.3	333.3	3.3	26.7	---	30.0	363.3	42	4
<1	3.3	50.0	3.3	56.6	3.3	6.7	---	10.0	66.6	7	1
1	---	26.7	16.7	43.4	---	3.3	---	3.3	46.7	5	<1
2	---	26.7	6.7	33.4	---	3.3	---	3.3	36.7	4	<1
3	3.3	33.3	3.3	39.9	3.3	6.7	---	10.0	49.9	5	1
4	---	23.3	3.3	26.6	---	---	---	---	26.6	3	---
5	3.3	16.7	3.3	23.3	---	---	---	---	23.3	3	---
6	---	13.3	---	13.3	3.3	3.3	---	6.6	19.9	2	1
7	3.3	16.7	3.3	23.3	---	---	---	---	23.3	3	---
8	---	16.7	6.7	23.4	---	6.7	---	6.7	30.1	3	1
9	---	10.0	---	10.0	---	---	---	---	10.0	1	---
10	3.3	3.3	6.7	13.3	---	---	---	---	13.3	2	---
11	3.3	6.7	10.0	20.0	---	---	---	---	20.0	2	---
12	3.3	13.3	10.0	26.6	---	---	---	---	26.6	3	---
13	---	6.7	6.7	13.4	---	---	---	---	13.4	2	---
14	3.3	---	---	3.3	---	---	---	---	3.3	<1	---
15+	16.7	3.3	3.3	23.3	---	---	---	---	23.3	3	---
Total	149.8	430.0	146.6	726.4	13.2	56.7	---	69.9	796.3	91	9
Percent	19	54	18	91	2	7	---	9	100		

a/ See Table 1.
b/ See Table 1.

Table 3.--Stand table for the Quaking Aspen Canyon damage survey block showing the species and diameter distribution of live trees and trees top-killed by the western spruce budworm, North Kaibab Ranger District, Kaibab National Forest, 1979 (Fig. 1, Appendix).

Size Classes a/	Live Trees/Acre b/				Top-killed Trees/Acre				Total Trees/Acre	Percent of Stand	
	DF	TF	SP	Total	DF	TF	SP	Total		Live	Top-killed
Seedlings	---	85.0	205.0	290.0	---	15.0	25.0	40.0	330.0	32	4
<1	5.0	5.0	120.0	130.0	---	---	20.0	20.0	150.0	14	2
1	---	5.0	90.0	95.0	---	---	20.0	20.0	115.0	10	2
2	---	---	125.0	125.0	---	---	20.0	20.0	145.0	14	2
3	---	---	50.0	50.0	---	---	10.0	10.0	60.0	6	1
4	---	---	30.0	30.0	---	---	5.0	5.0	35.0	3	<1
5	---	---	20.0	20.0	---	---	---	---	20.0	2	---
6	---	5.0	5.0	10.0	---	---	---	---	10.0	1	---
7	---	---	5.0	5.0	---	---	---	---	5.0	<1	---
8	---	---	---	---	---	---	---	---	---	---	---
9	---	---	5.0	5.0	---	---	---	---	5.0	<1	---
10	---	5.0	---	5.0	---	5.0	---	5.0	10.0	<1	<1
11	5.0	---	---	5.0	---	5.0	---	5.0	10.0	<1	---
12	---	---	---	---	---	---	---	---	---	---	<1
13	---	---	5.0	5.0	---	---	---	---	5.0	<1	---
14	---	---	---	---	---	---	---	---	---	---	---
15+	---	---	5.0	5.0	---	---	---	---	5.0	<1	---
Total	10.0	105.0	665.0	780.0	---	25	100	125	905.0	86	14
Percent	1	12	73	86	---	3	11	14	100		

a/ See Table 1.
b/ See Table 1.

Table 4.--Mean western spruce budworm egg mass density for 20 permanent plots sampled on the North Kaibab Ranger District, Kaibab National Forest, 1979 (Figure 1).

Center Number	Egg masses/meter square
1	0
2	0
3	58.1
4	17.8
5	30.0
6	62.9
7	43.2
8	0
9	20.8
10	0
11	0
12	28.9
13	13.5
14	21.8
15	48.3
16	22.9
17	53.9
18	28.9
19	13.4
20	52.4